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STUDY ON MULTI-TASK ORIENTED SERVICE COMPOSITION AND OPTIMIZATION PROBLEM OF CUSTOMER ORDER SCHEDULING PROBLEM USING FUZZY MIN-MAX ALGORITHM

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ABSTRACT

In a business world, handling multiple tasks with multiple enterprises practically is common. Cloud manufacturing (CM) is one of the service oriented paradigm to support for handling multiple tasks and multiple enterprises at the same time. The service oriented cloud manufacturing integrates and distributes manufacturing resources, transferring them into service for manufacturing industries as a manufacturing service and manages the service centrally. In cloud manufacturing platform, cloud manufacturing allows multiple users to request multiple services at the same time access the task in parallel by submitting their requirements. In this paper we consider the Customer Order Scheduling Problems (COSP) in cloud manufacturing. Here scheduling plays dynamic role in cloud manufacturing since multiple tasks for multiple users become chaotic for computing in cloud manufacturing. Based on this idea, we worked on the process of Service Selection and Optimization Scheduling Problem (SSOSP) for Small and Medium Manufacturing Enterprises (SMMEs), which is an important issue in practical implementation on cloud computing. We adopted mixed integer programming problem with mixed composition structure for SSOSP. In mixed integer programming, cost, time and quality are the main objective with incorporation of transportation time and transportation cost along with manufacturing cost and time. Finding optimized makespan of this SSOSP, we used fuzzy based min-max rule algorithm. The experimental result shows the benefit of the proposed method and the result concludes that the proposed algorithm can obtain high quality achievement with reasonable computation time.

Key words: service selection optimization scheduling problem, customer order scheduling problem, mixed integer programming, cloud manufacturing, min-max algorithm.

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1. INTRODUCTION

Nowadays, the main key issue addressed by manufacturing industry is collaboration and resource sharing among the manufacturing enterprises which leads to insufficient utilization of manufacturing resources; hence it is required to exploit these resources effectively. The traditional manufacturing system provides, customer to buy a finished product with lack of satisfaction, now the customers involving design and engineering for their need. Cloud manufacturing system gives the platform for customer to fulfill their expectation and satisfaction. Cloud manufacturing is a service oriented technology combines current manufacturing platform with cloud computing techniques and provides effective utilization of dispersed manufacturing resources and customer expectation. Cloud manufacturing enhances the production capacity and provides cooperation among the production chain as a result various enterprises are adopting cloud manufacturing to search, match and utilize. Nowadays the small and medium size enterprises have provided a great potential to fulfill customers expectation with their design and engineering. Cloud manufacturing provide powerful platform for association of small and medium size enterprises with customers. This platform is on-demand search and recommendation tool that identify all kind of manufacturing services such as design, engineering, testing, and packing in the product lifecycle to satisfy customer's requirement for customized manufacturing task [1].

Number of customers or a greater number of tasks handling for a period is very challenging one [2], among that the optimization of the tasks, need computational algorithm and must make schedule in proper manner. This study focused the mathematical model of customer order scheduling, the customer order is considered as a task and for optimality the task can be decomposed into different subtasks and scheduled using cloud manufacturing. Also, we focused, how to route a logistic the resources between small and medium size enterprises, how to handle the customer order occupancy and how to schedule subtask into available services. The task includes single functionality and multi-functionality, manufacturing can be performed as single functionality, the system using single CMs and multi-functionality the task can be decomposed into series of subtasks, such that at least one candidate CMs for each subtask can be offered.

In a cloud manufacturing, cloud manufacturing service is a scheme of one or more number of physical manufacturing resources whereas the resources in the form of hardware or software [3]. The challenges in cloud manufacturing are to complete the task optimally within available time frame and satisfying the constraints. The constraints include manufacturing cost, transportation cost, manufacturing time and transportation time, quality through selection and completion time of CMs [1, 21].The issues are handled by solving SSOSP, Also it is studied as a service composition and optimal selection problem (SCOSP).

Cloud manufacturing is based on cloud computing, which can be working over the internet or virtual network, even it is need physical transportation between CMs. Therefore, the additional constraints need to impose in service composition and scheduling problems in various locations. From the previous studies, the SSOSP and SCOSP problems in cloud

manufacturing system, most of the methods cannot be applied to cloud manufacturing system due to various quality of service (QoS) metrics. Here, we focused how to model the service selection for given task and scheduling it for manufacturing task with different subtask for operation, also, how to optimize route a logistic between the small and medium enterprises. Based on the analysis and working procedure of manufacturing industries for customer order scheduling, this paper proposes mathematical model for subtask scheduling for customer order in cloud manufacturing that assigns a CMs candidates for each subtask rather than the whole task. This model employs simultaneous processing a batch of tasks.

Considering the dispersed locations of manufacturing resources, we propose a model, the processing procedure is as follows. Cloud manufacturing is employed by middleware's, order request from the customers are received and sent to scheduler via the internet. The scheduler start working periodically after analyzing each task, the scheduler decomposes each task into number of subtask and allocates CMs candidates for each subtask with instructions through internet. Based on functional requirement of each subtask, CMs search the qualified CMs candidates and pool them into respective candidates. The subtask may have data dependencies, which result in the need for inter- machine communications. The subtask and inter-machine data transfer are scheduled such that the overall completion time is minimized.

The rest of this paper is described as follows. Section 2 provides the related literature review of this work. The problem description started from chapter 3 and it follows that service selection and mathematical formulation for optimization of subtask. Chapter 4 provides the algorithm and simulations and it followed by result discussion in chapter 5, chapter 6 is conclusion and future work.

2. LITERATURE REVIEW

Many researchers have been conducted research on scheduling in Cloud Manufacturing (CMs). [22] proposed energy adoptive immune genetic algorithm for cooperative task scheduling in CMs .The algorithm also provided good balance between diversification and intensification searching.[23]Explored the factors affecting resources allocation namely ,cost , capacity, load and credibility and the matching methods between these factors by proposing on demand task allocation strategies for work flow based CMs.[24] developed a resource configuration model to minimize the cost and delay with optimal product quality by decomposing each task into subtasks and obtained solution based on max inherit optimization for this model.[25]proposed a detailed procedure of decomposing and scheduling of multiple tasks for cost minimization [26] considered scheduling problem with the constraints such as cost, delay and quality by implementing cloud service for subtasks by adopting immune genetic algorithm based on artificial neural network to obtain the optimal combination. [27]considered the four robot deployment methods and three subtask scheduling strategies for three optimization objectives such as load balance of robots , minimizing overall cost and overall processing time.[28, 29] proposed a resource service composition and optimal selection method to minimize the time and cost by maximizing the reliability using particle swarm optimization. [30] Proposed a Genetic Algorithm to minimize the makespan and total cost of intra and inter plant transformation manufacturing cells. [31] Considered the bi-criterion problem of minimizing total setup time and to minimize the sum of customer order ranges by developing branch-bound algorithm to solve the proposed problem. [32] Proposed set of rules to convert 0-1 polynomial programming problems to 0-1 linear programming problems by replacing cross product terms by continuous variables rather than integer variables. [33,34] presented a genetic algorithm based heuristic method and a multi objective mixed integer programming model to minimize the total weighted completion time and total weighted travelling time.[35] studied four different mixed integer programming(MIP)

formulations for single machine scheduling problems. The results revealed that for certain problems a less frequently used MIP formulation, further presented two sets of inequalities to improve the formulation with assignment and positioned date variables. [36] Considered a customer order scheduling problem with the objective of minimizing total weighted completion time of the orders. To solve this problem, proposed a Novel quadratic formulation and then the formulation is transformed into an equivalent mixed integer linear programming model using linearization technique and exploited special structure to reduce the problem size by eliminating some variables and constraints.[37]Developed a new hybrid nested partition and mathematical programming model to create compliance between mathematical programming and heuristic/metaheuristic methods and also presented the applications of this approaches to the Local Pickup and Delivery Problem (LPDP) and Discrete Facility Location Problem (DFLP).

Limited research works are available for multi objective scheduling especially transportation cost between Hub, transportation time and quality of the product. [38] Done research on subtask scheduling by considering three constraints namely cost, delay and quality by implementing cloud manufacturing and adopted Immune Genetic Algorithm to gain the optimal solution. [39] Implemented Artificial Immune System based Algorithm to minimize overall cost and load balance for industrial robots in cloud manufacturing. However the many articles not included the transportation time, even some paper are available but there is no proper method for reducing the transportation cost and time. There is a substantial gap between SSOSP requirement especially transportation between enterprises, manufacturing cost and transportation cost, quality and effectiveness of scheduling. Thus, further research and investigation needs for service selections, and CMs need to consider realistic points in their proposed models to CMs commercially practicable in near future. Our research is going to address the above mentioned research gap.

3. PROBLEMS DESCRIPTION

A customer given an order, it can be consider as multi-task manufacturing service task. The order can be completed within expected cost and it must deliver within stipulated time, that is the order can be delivered within dead line with the average quality level of at least $MQ_{\min}$ % and this can be obtain from grading system of the SMMES. The multi-functionality manufacturing task problem allows binding a group of composite services together to perform multi-functionality manufacturing task problems. The multi-functionality manufacturing task problems decomposed into several subtask and search the qualified candidate CMs according to the functional requirement of each sub task and pool them into respective candidate CMs.

Based on this, select the appropriate composite CMs, from the pool of composite CMs for every subtask, and generate the possible CMs for each multi functionality multi task. Based on QoS criteria, select the suitable CMs from the possible ones as the candidate. According to QoS constrains, the candidate CMs grouped into multi functionality multi task and each group are integrated to perform each multi functionality multi task.

In this article, T is called task, let $T = (T_1, T_2, T_3, \dots, T_I)$denotethe multiple task, I($1 \leq i \leq I$)is the requesting user task. The QoS contains $Q(T_i) = (Q_{t1}, Q_{t2}, \dots, Q_{tI})$of each task and T_i can be decomposed into a workflow of subtask and denoted by $T_i = (st_j^1, st_j^2, \dots, st_j^i)$, j is number of subtasks. Also,‘ n’ registered SMMEs including man services is assumed.

Now the quality CMs for each subtask st_j^i are pooled into a candidate set $\{MCs_1^j, MCs_2^j, \dots, MCs_{kj}^j\}$, here kj is the number of candidate CMs in j^{th} services. The

numbers of CMs are related to a subtask $(st_j^1, st_j^2, \ldots, st_j^j)$ in the workflow of a multi functionality multi task T_i.

3.1. Service Selection

There are functionally equivalent CMs will be available for each subtask with different quality service metric. The challenging job is to choose the SMMEs, since the different SMMEs may have different parameter in fulfil the sub task in terms of different quality service metrics even though they are using same resources. To differentiate the CMs candidates, we consider manufacturing cost, manufacturing time and quality metrics which are the most important criteria to be optimized in the service selection. Considering CMs, manufacturing cost associated with utilization of CMs and time is associated with time interval between starting time and ending time of manufacturing respectively. Also, the average pass rate used for measuring the quality level. To find an optimal cloud service selection, a quality service metric for a cloud service selection should be derived from aggregating the corresponding metric of all selected CMs.

Dealing computation and manufacturing tasks especially those that are more complex, have the mixed type subtask is very difficult one. Subtask with mixed structure in cloud manufacturing, can be simplified to sequential structure. It applied directly to cloud manufacturing environment, it is necessary to study the logistic between the SMMEs. In this paper, we proposed mixed integer programming model for the subtask composition structure.

Selective sub task coming to the system and the system has to select suitable subtask among the pool of subtask. Each sub task has to process any one of the available system in the manufacturing structure. The probability of selecting st^{th} subtask for the system is $P_{prob} = 1$. The table (1) shows the notation used for formulation of SSOSP.

Table 1 Notation for SSOSP

CSST	cost in the selective subtask	Tr	Transportation
TSST	completion time of selective subtask	$TrT_{i,j}$	Transportation time between the SMMEs
I	Multiple Tasks	$x_{st,r}$	1 if st^{th} subtask is performed using r^{th} MCs's
l	Index of CMs	$Ship_{start,st}$	Shipment from the starting point of supplier of first subtask
i,j	Index of location of SMMEs	P	Index of manufacturing subtasks(st,u=1,…,st)
st,u	Index for subtask	LOC_{end}	Location of transportation ends
CTr	Cost of Transportation	LOC_{start}	Location of transportation starts
TrT	Time of Transportation	$y^{i,j}_{start}$	1 if i^{th} and p^{th} subtask performed location i and j respectively and there is a direct transportation between these location; 0 otherwise
C_{mgf}	Manufacturing cost	$MgfT_{st}$	Manufacturing time for subtask
$x_{i,j}$	1 if st^{th} subtask is performed using r^{th} CMs ; 0 othewise	SMgf(Pu)	Starting time of manufacturing process st^{th} subtask.
r	Index for SMMEs	EMgf(Pu)	End time of manufacturing process st^{th} subtask
R_{st}	Pool of cloud manufacturing qualified service set for st^{th} subtask	$\mu_{u,k}$	1 if st^{th} subtask is performed using r^{th} CMs before starting its occupied time; 0 otherwise
q	Index of supplying and delivering subtask in addition to manufacturing subtask(q,p=srart,1,…,st,…, end)	C	Cost
$w_{i,j}$	Transportation weight from between q and q+1 subtask	T	Time
$y^{i,j}_{q,q+1}$	1 if transportation from i to j,q^{th} subtask performed in i,j	MC_{cus}	Maximum cost that customer willing to pay
T_{min}	Time minimization	DD_{cus}	Production delivery deadline specified by the customer
C_{min}	Cost minimization	Tr_{unit}	Transportation per unit
T_{mgf}	Manufacturing time	TrT_{unit}	Transportation time per unit
D	distance		

$Min\ C_{\min} = \sum_{st=1}^{p} P_{prob}\ CSST_{st}$ (Cost in the selective sub task selected among the alternative sub tasks)

$Min\ T_{\min} = \sum_{st=1}^{p} P_{prob}\ TSST_{st}$ (Task completion time in the selective sub task selected among the alternative sub tasks)

The main objective of this paper is to minimize the total cost, time with respect to transportation and production. Earlier the manufacturer used to calculate the price based on the quotation given by organization for each subtask, but it was missed some of the cost compare to the actual cost for so many factors. Here we include some different factors such as transportation cost and distance, commodities weight and rout of their destination. The equation number (1) is formulated based on these factors.

$$C\ Tr_{i,j} = D_{i,j} CTr_{unit} \quad (1)$$

$$Tr\ T_{i,j} = D_{i,j} TrT_{unit} \quad (2)$$

Also, we define the variable cost for delay delivery on the shipment from each destination in

$$Min\ C_{\min} = \sum_{st=1}^{p} \sum_{r \in R_{st}} C_{Mfg} x_{st,r} + \sum_{q=1}^{p} \sum_{i=1}^{m} \sum_{j=1}^{n} CTr_{i,j} w_{i,j} y_{q,q+1}^{i,j} P_{prob} \quad (3)$$

The equation (4) shows that minimize the completion time of the task which incorporates the manufacturing time, transportation time between the destinations, and waiting time of the resources. Here the manufacturing time is the promised time by manufacturer after sending manufacturing sub task to manufacturing centre, includes setup time, processing time, and maintenance time. Based on the equation (2), transportation time is depend on the distance that should be logistic time for unit distance between the centres, also, the waiting time before start of a manufacture process.

$$Min\ T_{\min} = \sum_{st=1}^{p} \sum_{r \in R_{st}} T_{Mfg} x_{st,r} + \sum_{q=1}^{p} \sum_{i=1}^{m} \sum_{j=1}^{n} TrT_{i,j} w_{i,j} y_{q,q+1}^{i,j} P_{prob} \quad (4)$$

The another objective function is quality of service metrics(Maximum quality), it can be calculated through average pass rate of the selected SMMEs as presented in the following equation

$$MQ_{\min} = \frac{1}{s} \sum_{s=1}^{s} \sum_{st \in R_{st}} pass_r x_{st,r} \quad (5)$$

We used the following different constraints for getting the simultaneously optimize the main objective function. The constrain (6) gives the mathematical formulation that there is a shipment from the starting point of supplier to the where the first sub task is going to perform. The constraint (7) gives the transportation between the manufacturing centres to perform the successive subtask. The shipment of last manufacturing centre to customer is expressed by the constraint (8) and the constraint (9) ensuring that a sub task is performed by only one manufacturing centre.

$$x_{st,r} \le ship_{start,st}^{Loc_{start}Loc_r} \forall r \in R_{st} \quad (6)$$

$$x_{st,r} + x_{st+1,k} \le 1 + ship_{1,st}^{Loc_1,Loc_r}\ \forall st < P, r \in R_{st}, k \in R_{st+1} x_{st,r} \le ship_{start,st}^{Loc_{start}Loc_r} \forall r \in R_{st} \quad (7)$$

$$x_{st,r} \le ship_{start,st}^{Loc_{start}Loc_r} \forall r \in R_{st} \quad (8)$$

$$\sum_{r\in R_{st}} x_{st,r} = 1 \ \forall st \tag{9}$$

The equation (10) and (11) estimate the starting and ending of sub task respectively since sth sub task cannot perform until the completion of the proceeding sub task, sometime the transportation time and waiting time may require between two consecutive sub tasks also. To calculate the starting time of the sub task, manufacturing time, transportation time, and all preceding sub task should be added with its waiting time. Similarly, sub task ending time is sum of starting time and its corresponding manufacturing time.

$$\sum_{i=1}^{m}\sum_{j=1}^{n} TrT_{i,j}\, y_{start,1}^{i,j} + \sum_{st=1}^{p-1}\sum_{r\in R_{st}} MfgT_{st,r}\, x_{st,r} + \sum_{q=1}^{p-1}\sum_{i=1}^{m}\sum_{j=1}^{n} TrT_{i,j}\, y_{q,q+1}^{i,j} \ \forall P \tag{10}$$

$$SMfgP_u + \sum_{k\in R_u} MfgT_{u,k}\, x_{u,k} = EMfgP_u \quad \forall u \tag{11}$$

The equations (12) and (13) are the constraints which are schedule a sub task to selected cloud manufacturing centres from start or finish before occupancy. Here μ is the variable which allows only one of these constraints to activate for each sub task. The other constraints (12) and (13) gives the quality of service requirements specified by the customer in terms of cost and time, also, last one, equation (16) is restrictions of the related decision variables.

$$SMfgP_u + Mfg \quad \mu_{u,k} \geq EMfg_o Tx_{u,k} \ \forall u, k \in R_u \tag{12}$$

$$EMfgP_u \leq SMfg_0 Tx_{u,k} + Mfg(1-\mu_{u,k}) \quad \forall u, k \in R_u \tag{13}$$

$$C \leq MC_{cus} \tag{14}$$

$$T \leq DD_{cus} \tag{15}$$

$$x_{st,r}, \mu_{u,k}, y_{i,j}, y_q^{i,j} \in [0,1] \ SMfgP_u, EMfgP_u, w_{i,j} \geq 0, \forall i, j, st, r, k, u, p \tag{16}$$

3.2. Overall Objective function

The proposed models for solving SSOSP are minimizing the cost and time and maximizing the production quality for the customer order. Finding optimized solution of all three objectives is not possible. So, we combined all three objectives and can be optimized the overall objective function. The range and measurement of the objective function are may be different significant. Therefore, the different objective functions cannot be summed directly for overall objective function. For solving this issue, we proposed fuzzy logic method for finding optimal value of overall objective function. Zadeh was introduce the fuzzy logic to deal with problems in which sources of uncertainty is occurred. Fuzzy logic provides multi valued membership function to define an objective function rather than the binary of 0 and 1. Let X be a fuzzy set of objectives and whose elements are x. The membership in fuzzy set A of X is the characteristic function of μ_A such that $\mu_A = \begin{cases} 1 \ iff \ \ x \in A \\ 0 \ otherwise \end{cases}$.

The fuzzy inferences are defined as maps and input and output spaces. IF-THEN statements are called rules of inferences which are expressed in the form of IF (antecedent) THEN (consequents). Whatever input data being converted into fuzzy membership values is called fuzzification and the process of obtaining a crisp value from the inferences is called defuzzification. To find optimal value of the objective function, we have to identify the fuzzy variable which is uncertain values or unclear boundaries. In this study, the fuzzy variables are MC, MT, MQ as manufacturing cost, manufacturing time, and manufacturing quality. The

highest interest of customer is bigger value in the quality and smaller values in cost and time. Therefore, CMs need to be determined according to the customer interest. Here each objective function is defined as fuzzy variable. The individual objective function can be fuzzified as follows.

MC= (current value – minimal values)/(maximal values – minimal values) the similar concept used for MT, MQ also. These variables are useful measure for calculating the CMs according to the customer interest. The variables are summarized as follows

$$MC = \begin{cases} high(\mu_{mch}) \\ average(\mu_{mca}), \\ low(\mu_{mcl}) \end{cases} \quad MT = \begin{cases} high(\mu_{mth}) \\ average(\mu_{mta}), \\ low(\mu_{mtl}) \end{cases} \quad MQ = \begin{cases} high(\mu_{mqh}) \\ average(\mu_{mqa}) \\ low(\mu_{mql}) \end{cases}$$

Next, we must define the membership function, which is linguistic labeled for the specifying the universe of discourse of fuzzy variable.

4. FUZZY INFERENCE

The customer relationship depends not only cost and quality, but delivery performance is also critical. Therefore, the fuzzy variable we consider manufacturing quality is the first priority, cost is the second priority, and manufacturing time is the third priority. The inference rule matrix framed for three variables are as follows. If quality (MQ) low and whatever value for manufacturing cost and transportation is 0(rejected). If MQ is average and MT is low, and MC is low then the priority value is 1. If MQ is average and MT is low and MC is average then the priority is 2, similarly the other rules are defined.

Table 2 Fuzzy priority table

MQ	**MT**	**MC**		
		low	average	high
low	low	0	0	0
	average	0	0	0
	high	0	0	0
average	low	1	2	3
	average	4	5	6
	high	7	8	9
high	low	10	11	12
	average	13	14	15
	high	16	17	18

Here we propose a fuzzy min-max composition method for decomposition of fuzzy membership values. The composition relation can be defined as $A: X \to [0,1]$ and B: Y → [0,1] then the relation $C = A^\circ B \in X \times Y \to [0,1]\ and\ \mu_C(x,y) = \sup_{z \in \mu z} min\{\mu_A(x,z), \mu_B(z,y)\ where\ A = f(X,Z)$, $B = f(Z,Y), \forall (x,y) \in X \times Y$

$$If\ \forall x \in U,\ then\ A \cup B = \{\mu_x(x) = max(\mu_A(x), \mu_B(x))$$

Therefore the overall objective function is defined as

$$\begin{aligned}\boldsymbol{O_{obj}} = \boldsymbol{max}\{&\boldsymbol{min}(\mu_{mch}, \mu_{mth,}\mu_{mqh}), \boldsymbol{min}(\mu_{mch}, \mu_{mth,}\mu_{mqa}), \boldsymbol{min}(\mu_{mch}, \mu_{mth,}\mu_{mql}),\\ &\boldsymbol{min}(\mu_{mch}, \mu_{mta,}\mu_{mqh}), \boldsymbol{min}(\mu_{mch}, \mu_{mta,}\mu_{mqa}), \boldsymbol{min}(\mu_{mch}, \mu_{mta,}\mu_{mql}),\\ &\boldsymbol{min}(\mu_{mch}, \mu_{mtl,}\mu_{mqh}), \boldsymbol{min}(\mu_{mch}, \mu_{mtl,}\mu_{mqa}), \boldsymbol{min}(\mu_{mch}, \mu_{mtl,}\mu_{mql}),\\ &\boldsymbol{min}(\mu_{mca}, \mu_{mth,}\mu_{mqh}), \boldsymbol{min}(\mu_{mca}, \mu_{mth,}\mu_{mqa}), \boldsymbol{min}(\mu_{mca}, \mu_{mth,}\mu_{mql}),\\ &\boldsymbol{min}(\mu_{mca}, \mu_{mta,}\mu_{mqh}), \boldsymbol{min}(\mu_{mca}, \mu_{mta,}\mu_{mqa}), \boldsymbol{min}(\mu_{mca}, \mu_{mta,}\mu_{mql}),\\ &\boldsymbol{min}(\mu_{mca}, \mu_{mtl,}\mu_{mqh}), \boldsymbol{min}(\mu_{mca}, \mu_{mtl,}\mu_{mqa}), \boldsymbol{min}(\mu_{mca}, \mu_{mtl,}\mu_{mql})\}\end{aligned}$$

The above inference rule is giving the proper matching of candidates CMs. For example, the quality is high and cost is medium and manufacturing time is low then the priority is 13, which is if the priority is 13 then the corresponding objective functions giving the sequence of CMs with respect to subtasks.

5. RESULT AND DISCUSSION

We assumed that a cloud manufacturing is giving platform for service – oriented manufacturing system to 10 SMMEs. The logistic between the different SMMEs can be routed through directed network. A customer placing an order and requesting customized order for minimized cost and stipulated time and average quality level.

The table 5 shows that different parameters in solving the COSP and the value of customer promised cost, customer delivery time, customer expected quality and CTr unit. CTr time per unit parameter have been selected based on the real time setting and the other parameter have chosen randomly. The task defined as a subtask and the transportation start from the supplier's location and different manufacturing subtask need to be performed before transportation ends. In this paper we defined the Distance d_{ij} between the enterprises and given in table 3.

Table 3 Distance between the enterprises

SMMEs Index	1	2	5	6	7	9	11	15	16	17
1	0	242	332	432	128	365	463	275	244	360
2	242	0	126	223	435	342	321	248	144	343
5	332	126	0	410	330	394	475	371	215	199
6	432	223	410	0	183	184	187	425	214	215
7	128	435	330	183	0	299	135	340	434	234
9	365	342	394	184	299	0	174	247	496	343
11	463	321	475	187	135	174	0	125	217	187
15	275	248	371	425	340	247	125	0	240	213
16	244	144	215	214	434	496	217	240	0	197
17	360	343	199	215	234	343	187	213	197	0

Also the COSP is decomposed into six subtasks $st_{k,}$ k= 1,2,…6(st1, st2, st3, st4, st5, st6) and CM platform matches the services with subtasks according to their requirement. For each subtask several SMMEs but with different quality metrics are available even some time one or more SMMEs have the same metrics. The table 4 gives the generated data of manufacturing cost per unit and manufacturing time for the case of SMMEs and their cloud manufacturing indexes.

Table 4 Subtask cost, time and quality with respect to SMMEs

S.No	SMMEs Index	Pass rate	Occupied time	Manufacturing cost per unit (Rs in ten thousands)/Time(week) per unit					
subtasks				st1	st2	st3	st4	st5	st6
1	1	0.93	2-4	3.5/2			3.2/2.5		
2	2	0.75	0-3		8.3/2.1				
3	5	0.70	3-4	9.2/1.2					
4	6	0.95	2-7		10.2/2.5			10.7/2.3	
5	7	0.87	2-4			13.2/3			
6	9	0.76	5-7		8.2/1.2		9.3/2		
7	11	0.87	3-8	7.7/3				8.2/3	
8	15	0.82	2-6			11.2/3.5			12.1/4
9	16	0.81	4-7		4.2/2.3				
10	17	0.79	4-8	14.2/3					13.7/2.8

In cloud manufacturing, CMs platform matches the services with subtasks according to their requirements based on conformation of the user and then sends the manufacturing invitations to corresponding services. The aim of the study is to determine the optimal service selection and scheduling which includes selecting the optimal CMs for performing each subtask, the routing optimization from SMMEs, and outlining when each subtask starts and ends with the consideration of service occupancy.

Table 5 parameters in solving the SSOSP.

S.No	parameters	Values	S.No	parameters	Values
1	i : Location of SMMEs	17	6	w_t: time parameter	0.4
2	r: Index of MCs	20	8	w_q: quality parameter	0.2
3	st: Number of subtask	6	9	C_M: max.cost customer willing to pay	44000
4	$W_{i,j}$: Weight of transportation	40 if i<6 and 200 if i>=7	10	U_{TC}: Unit transportation cost	0.003
5	Loc_{strart}	15	11	U_{TT}: Unit time transportation cost	$463x10^{-6}$
6	Loc_{end}	10	12	T_{max}: deadline	14
7	w_c: cost parameter	0.4		Q_{max}:	75

According to the table 5, transportation starts with supplier locations. Seventeen different SMMEs need to perform 6 subtasks before transportation end. In addition to that the data of SMMEs and their CMs as well as the inter-location geographical distance between the locations have been presented in table 3. From the table 5, we can calculate the other parameters such as $TC_{i,j}$ and $TT_{i,j}$ based on their definition. The range of values of ideal solution obtained from the corresponding payoff table, as well as the value of the overall objective function (OF) demonstrated as follows. The lower bound value of manufacturing cost OF is Rs 38.3 in thousands and the upper bound equals to Rs72.4 in thousands when $W_C = 1$ and W_T=W_Q=0. Value of Time OF falls between 1.2 weeks and 7.5 weeks the value of quality of objective function is in the range from 81% to 95%. Using min-max algorithm as defined by min-max formula, the value of overall OF is equal to 0.73 which is highest value. If we are not involving the transportation, cost of the OF according to min-max algorithm is 53 thousands with maximum time of 4 weeks and average quality of 85.8%. The optimized sequence of flow of the subtasks performing in SMMEs is 11 → 9 → 15 → 1 → 6 → 15with the transportation cost of Rs.4.659 thousands per unit. Here two scenarios put forward to explain these outcomes. First scenario is considered without transportation cost. Result shows that there is a considerable reduction in the value of corresponding OF. The second scenario is

considered the transportation cost and time. The model selects SMMEs completely based on CMs.

6. CONCLUSION AND DISCUSSION

In this paper, we studied manufacturing cost, manufacturing time, transportation time and cost of goods transportation. A fuzzy rule based multi task scheduling model is proposed for cloud manufacturing. Here we considered manufacturing cost, manufacturing time and transportation time between the small and medium manufacturing enterprises and quality as the one of the constrains. Based on proposed fuzzy rule, all three objective functions classified as small, medium and high, and used min max rule for finding optimal sequence of the tasks. Transportation is the main significant factor in cloud manufacturing since that can affect the task scheduling in greater way. Dynamic calculation fulfilled the subtask and service utilization. Our min max algorithm results indicated that scheduling longer workload tasks with high priority is better chances and attained the quick optimal solution. Future work will be considered for continuous arrivals of customer order with different time and different constrains.

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